DOCUMENT RESUME

ED 129 628 SE 021 498

AUTHOR Poulsen, Sten C.
TITLE The Study-Methods in Mathematics Project. I, Background, Assumptions and Perspectives. Report No. 18.
INSTITUTION Danish Inst. for Educational Research, Copenhagen.
PUB DATE 75
NOTE 36p.; Not available in hard copy due to marginal legibility of original document

EDRS PRICE MF-$0.83 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS *Adult Basic Education; Adult Education; Individualized Instruction; Instruction; Learning; *Mathematics Education; *Program Descriptions; *Research Projects; *Study Skills
IDENTIFIERS Denmark

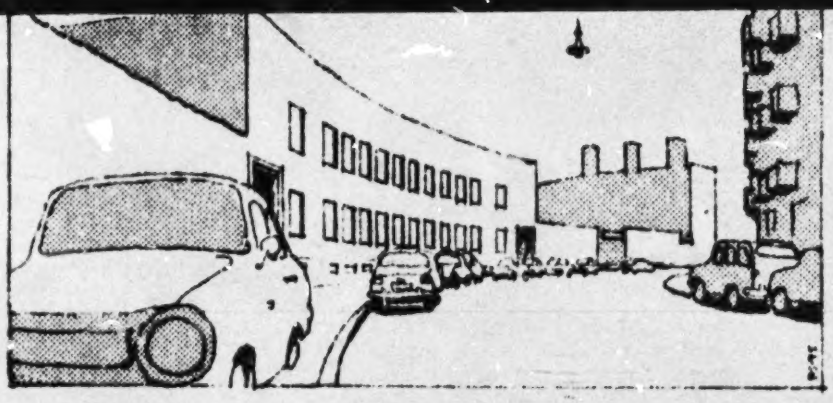
ABSTRACT

This is the first of several reports on the "Study Methods in Mathematics Project;" the goal of the project is to describe and develop practical study methods which are especially suitable for adults' study of mathematics. In this report, the background of the project is discussed in terms of experience from research on the study habits of mathematics students, general studies in literature on mathematics education and study techniques, clarification of research methods toward process/product centered developmental research, and the author's own school and study experiences. In a second section, the choice of research subjects, the learning situation, and the project's organization are discussed. Finally, comments on teacher-directed learning in the schools and on self-directed and collective-directed learning situations are included. (DT)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

U.S. DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.



ED129628

THE STUDY-METHODS IN MATHEMATICS PROJECT

I.

BACKGROUND, ASSUMPTIONS AND PERSPECTIVES

Sten C. Poulsen

BEST COPY AVAILABLE

2

Report
No. 18
1975

SE021498

The Danish Institute for Educational Research
28 Hermodsgade. Copenhagen 2200
Denmark

ED 129 498

The purpose of this series of mimeographed publications from the Danish Institute forEducational Research is to stimulate feed-back on material of a provisional and sketchy nature, from educators and psychologists engaged in practical work and/or scientific research.

Attention should also be called to the Institute's further publishing activity: those publications for general distribution (published in book form by Munksgaard Forlag, Copenhagen); and reprints from books, articles, etc., and educational tests, all of which can be purchased directly from the Institute. Information on publishing activity can be found in the Institute's Yearly Report published in mid-September.

This report may be copied in whole or in part, though kindly with an explicit statement of source.

The reports are not for sale, but can be obtained in limited numbers, free of charge, by contacting directly the author of the publication in question.

INFORMATION ON THE MIMEOGRAPHED REPORT No. 18 FROM

THE DANISH INSTITUTE FOR EDUCATIONAL RESEARCH

TITLE : "The Study Methods in Mathematics Project: Background Assumptions and Perspectives."

AUTHOR : Sten C. Poulsen, Assistant research director

LOCATION : The Danish Institute for Educational Research
Hermodsgade 28, DK-2200 Copenhagen N, Denmark
Telephone: Internat.: +45 1(72) TAga 10.140

DATE : Danish manuscript completed december 1974.

KEY CONCEPTS: Study techniques, study methods, mathematics instruction, adult education, self-directed learning processes, collective learning.

SUMMARY This is the first of several reports on "The Study Methods in Mathematics Project". The goal of this project is to describe and develop practical study methods, which are especially suitable for adults' study of mathematics.

Among the preconditions of the project can be mentioned: experience from research in the study habits of mathematics students, general studies in literature on mathematics education and study techniques, research methods clarification toward a process/product centered developmental research, and the author's own school and study experiences.

The project is characterized by a social engagement: a special effort being made for educationally underprivileged adults. The mathematics discipline was chosen as the object of study, partially because precisely this discipline can appear to function as a social filter in education.

The investigation's immediate goal is an improved study methodical adjustment to a teacher-directed instruction situation. The more distant perspective, however, is collective learning, which implies a self-directed learning process and reciprocal teaching.

LENGTH : 30 pages

FOREWORD

As part of the "Study Methods in Mathematics Project", there will de published a series of duplicated reports, similar to this, which together will describe the most important aspects of the project, and will, at intervals, bring the latest collected experiences. The next report will thus describe the goals and most important fundamental concepts of the project.

The reports, which are duplicated in only a few copies, are meant to stimulate feed-back from educationalists engaged in teaching and from educational psychologists engaged in educational research.

There will be attempted a form of exposition that is easily assimilated by both groups of readers.

TABLE OF CONTENTS

INFORMATION ON THE REPORT	1
FOREWORD	3
TABLE OF CONTENTS	4
PROJECT SUMMARY	5
INTRODUCTION	6
PROJECT BACKGROUND	7
ASSUMPTIONS AND VALUE JUDGEMENT	17
THE PROJECT'S ORGANIZATION	24
PERSPECTIVES	25
CONCLUDING COMMENT	28
REFERENCES	29
DUPLICATED REPORTS FROM THE DANISH INSTITUTE FOR EDUCATIONAL RESEARCH	32

PROJECT SUMMARY

The primary goal of the project is to develop practical study methods, which are especially meant for use by adults studying mathematics - partially in classroom situations and partially by more unstructured, self-directed learning processes.

The first experimental subjects are the oldest students (35-55 years) in a number of highschool classes for educationally underpriviledged adults. The experimental situation itself is built upon the use of ITV (Internal TeleVision), interviews and verbalization of thoughts and feelings during the learning process; and focuses upon a detail-analysis of the single subject's individual learning process

Preliminary experiments have been completed with promising results, and in December 1974 began the actual experimental and developmental work on the project.

INTRODUCTION

If one reads research reports, the cronologically arranged report format can often astonish the reader with the overwhelming impartiality of its internal structure: the one segment apparently following the preceding, both logically and naturally - there do not appear to be any other possibilities, nor are there any loose ends marring the impression given.

The following sections are thought of as a humble attempt to discontinue the use of such overstructured de-- scriptions, which claim to be self-sufficient - whole structures justifying themselves.

By this means is also met the criticism of the last few years of an inappropriate, if not directly manipulative, self-censoring by researchers of the attitudes experiences, events, incidental impulses, biases, values, etc., etc.; all of which actually lie behind the choice of the research object and the determination of both closer and more distant goals for the individual projects.

Thus, the intention here is to give a more open description of the basis of this specific project.

PROJECT BACKGROUND

The H.C. Ørsted Project 1966-1970

In 1966 the Student Council of the Mathematics-Psysics Department became anxious over the high percentage of student failing the general methematics course (Mathematics-1) at Copenhagen University's H.C. Ørsted Institute. This course of study was the major preoccupation of the 1st. year mathematics students, and was required also of students in related fields, ie. psysics, geography, etc. M-1 was, in short, a bottleneck.

Contact was made with the author through the Institute's Department of Didactics, where he was a trainee in educational research at that time. This resulted in an interview investigation in 1966-67 (Poulsen, 1968), where it was sought to determine which study habits were the most appropriate in regards to passing the M-1 course of study.

A set of study habits - which taken together correlated significantly with the study result of the 1st. year - were successfully pointed out; and a dubplicated practical guide--line was written, tested and distributed to the students (Poulsen, 1968 og 1969a).

Three years after the initial investigation (in 1969), the same group of students was questioned about their study progress by means of a mailed questionaire (45 out of 46 responded). Half of the respondents still studied mathematics. The other half had dropped out of the mathematics study, but had begun on other forms of educations, where they managed well (Poulsen, 1970).

If one did a status today, there would appear to be three major lessons to be learned of these investigations: First, that the study-methods aspect of mathematics learning is a promising idea for attacking this question, but that interviews and questionaires alone can not give satisfactory data. Secondly, that these university youths are already

on the right side of our society's educational gap, and therefore are perhaps not the correct group to invest the minimal pedagogical-psychological research resourses in. The third lesson is that there exists an extraordinarily close correlation between study methods, teaching material, teaching methods, and examination reguirements. Study methods applicable to high school are simply nonapplicable to a university environment.

Research on the learning of mathematics

This section is based upon a somewhat more extensive discussion of some research reports (Poulsen, 1971) - an investigation, which it is my desire to develop to an autonomous report in a similar format to this .

If one looks at what psychologists have investigated in the teaching of mathematics during the past ten years, it will become apparent that they have, almost without exception, worked with the presentation of the material to be learned. They have modernized the curriculum, ie., they have tried to write textbooks in a broader and more easily comprehensible style, and have introduced audiovisual aids. They have been concerned with the sequence of presentation and with the tempo in which the teacher should present the material (for example, in both programmed teaching and the work with general textbooks); and they have sought to present the material in such a way that the pupil is stimulated to discover the mathematical concepts himself. There have been made dozens of investigations in these areas, buth they are all primarily interested in what the teacher has to do to make the learning more stimulating and easy.

The research where there is made an attempt for a better understanding of how the pupils thought, while they learned mathematics, falls also into this previously mentioned category. These projects conclude in concrete suggestions to new teaching materials and directions to mathematics teachers and not to the pupils (Dienes, 1960; Kaplan, 1964; Land, 1963).

Beyond the themes mentioned here, some of the things researchers have worked with are: "independent study" methods; the relative effects of differing teaching methods on learning; correlating the characteristics of the pupils, who have taken part in "effect" research; and finally with the development of tests for use in determining proficiency in subject matter, intelligence, attitudes, etc..

It is remarkable that in this large and varied group of reports one only finds a few investigations of the pupils' individual study-methods. The reason for this can be difficult to determine, but a lack of interest by educationalists and a lack of research instruments and methods have perhaps been the most important factors.

Buswell & Kersh (1956) and Newell, Shaw & Simon (1960) have attempted to describe thought processes in the solving of mathematical problems. In both investigations, the results were meaningfull descriptions, which clearly showed the individual variations.

Kaplan (1964) and Tough (1967) were interested in how much individuals themselves could direct their own learning activities with beneficial results and in both cases it proved to be possible.

Poulsen (1968, 1969[b] and 1970) has done a longitudinal study of individuals' study habits (the H.C. Ørsted Project) and found that it was possible to describe this aspect of the students' course of study by employing an interview--questionaire method; and he found that university-level students did not appear to be able to determine appropriate study methods for themselves without assistance.

The results of these investigations can be intrepreted such that in reality it is possible to achieve practical descriptions of many aspects of the individual learning processes in the learning of mathematics. It must be remembered though, that in this research the subjects have been, for the most, high school and college students. Whether such results can also be obtained when the research subjects are not used to studying, will be determined only with further research.

If one now considers, which type of research is most capable of providing knowledge of the individual learning processes, it will become a question of whether it would not be of positive value to combine all the research methods used to date, in an intensive investigation of individuals' learning of mathematics.

Buswell & Kersch and Newell, Shaw & Simon directed their subjects to describe, either orally or in writing, their reasoning, tape-recorded this "thinking aloud" and used the subjects' notes together with these tapes in the following analyses. Kaplan also attempted to register the learning processes by means of tape-recordings and the subjects' notes.

On the other hand, Tough and Poulsen did not attempt to acquire detailed information on the actual problemsolving phase, but rather obtained descriptions of a longer process in individual learning activity, by means of interviews and questionaires.

If one combined the registration of "thinking aloud" and analyses of the subjects notes with structured interviews; and if one further controlled the results with direct observations, it could be possible to obtain a more practical and deeper understanding of the individual learning processes.

Research on learning processes

This section begins with a many paged quote from another report from the Danish Institute for Educational Research (Jensen et. al. 1974, pp. 3-6).

> "The background for the project is partially research-methodical contemplations on the process-product discussion and partially an estimation of the practicality of the contents in developmental descriptions.
>
> Prior to the 1960's, one could ascertain an increasing dissatifaction with research in problemsolving psychology. Since the pioneers, Selz, Dunker, etc., had begun using the so-called "Thinking aloud method", there have not been any important changes methodically

or conceptionally. A large part of the investigations are described in such a way so that the activities appear as somewhat advanced "party games". The astonishment that "highly intelligent" people also had difficulty solving problems of various nature is something outstanding in the result descriptions. The investigations, very often, can be said to give synchronous descriptions, ie. descriptions of the more or less specific competance of people grouped after various dimensions: age, sex, socio-economic status, IQ, etc.

Post-hoc error analyses dominated in the development and preparation of results, with the number of solutions as an outstanding parameter; while the activities which lay prior to the, (of the researcher), defined situation, ie, s[illegible]ing/not solving, were not considered.

Other background factors for the investigation are, as mentioned, developmental theories - especially that of Piaget. His starting point had been, first and foremost, the development of knowledge. Due to general biological considerations though, he found it necessary to study the development of comprehension in man, an thus came to his formulations on the development of knowledge. Development in this field can be said to be something in the direction of a gradually more explicit dialectics between man and his environment.

It is presumably still reasonable to characterize Piaget's model as a stadia-model, ie., the life-cycle of an organism (ontogenetics) is described as a sequence of <u>developmental stages</u>, where each stage represents the comprehensive summations of the organisms competence, as it exists at a given point in time. As well as being used as ontogenical points of reference, the description of these developmental stages was stated by Piaget, in a logical-mathematical language, as an attempt to expose the individual's construction of his environmental understandign. Behavior, as it was

explained by the many original experiments, was described by means of logical-mathematical elements, with the many possibilities of interpretation this system enjoys. This interpretation of behavior is one of the many points in Piaget's model worthy of discussion. The reporting of these experiments is known for the difficulties in controlling this interpretation and the repetition of these many experiments has not been particularily clarifying, in spite for their numbers. Most investigations, though not all, can still be seen as contributions to one of two groups either in agreement with or disagreeing with Piaget's results. The sizes of the two groups does not in themselves bring greater insight into the experiments' range of reliability.

"Two tendencies - 1) dissatisfaction with product descriptions within problem solving research which resulted in a changing of priorities towards developmental models as the basis for observing problem-solving in a larger context; and 2) a desire for a more constructive interference oriented description of (cognitive) development - led to reflection the practicability of a problem described by the American psychologist E.R. John (1957). We found that it had possibilities and in the following we will give the basis for this decision.

The problem with "product investigations" is, of course, that one observes and registers only a little segment of something much more complex; in that, one registers the " proposed solution " only and characterizes it as either right or wrong. The quotation marks stress a certain degree of vagueness around the process-product concept. The discussion on this theme has sometimes emphasized process and product as two essentially different things. The products was one thing, the process something totally different. On the basis of general descriptive theoretical considerations, we

are in principle in disagreement with this differentiation. These considerations are too far from the point to discuss here, and, of necessity, we are able only to refer to an outline presentation (Jensen, 1970 Ch. II; Nissen, 1970, Ch. I).

As an assumed definition of these terms, we can say here, that process is equated with a sequence of products. At the same time, we prefer to speak of a series of situations, in agreement with the named references. We wish to stress the fundamental arbitrariness, partially in the delimination of a process one is interested in, at any given time, including problem"; and partially in a particular process's "situation density", (ie., the number of situations in the series). The smallest possible series, though, will be two situations. This means that the delimination of a series must be dictated by a purpose or goal as it is not found in nature. In our meaning it must take its starting point in a developmental and pedagogical model.

The most important characteristic of the reasonings for "process" studies, or as we prefer to call them, the studies of solving-series, is that the phenomena psychology is concerned with, can be investigated by many different means; and correspondingly a given state can, dependent upon circumstances, lead to many different results.

This situation is, at a certain descriptive level, different from another, which exists in the employment of physical objects, where one can, to a larger degree, describe a process, which has led to a certain result, precisely on the basis of that result. An interference--oriented developmental psychology, instead of a mere exposing of personality changes, must therefore have as its basis the study of processes; cf. a requirement of the smallest descriptive element. The problem is therefore, to register something more extensive than

the proposed answer. That is to say, we must maintain the reflections the subject makes, which lead to this answer. More generally, we will maintain that one must have externalized larger segments of the process rather than only the proposed answer.

We have previously mentioned the "thinking aloud" method as a meaningfull contribution to process-study methodology. Under "favorable" conditions it maintains aspects of the solving process, that can contribute to a variable appraisal of the actual proposed answer. As is well known though, there are many problems connected with the use of this methodology: both what one could call the "technical" problems and also the general problsms of principle. These last are connected with the question: "Is it the same process that goes on in the subject, when he is 'thinking aloud' as when he is not." (see for example, Neisser 1967, Ch. I.) One could thus speak of a more of less appropriate externalizing, in relation to the goals of a particular investigation. The groundrules for externalizing are found in the situation that the subject is placed "in"; ie., the restrictions, with their associated observation categories, which the research situation calls to the attention of the subject.

Externalizing in the task, which the apparatus described here is the basis for, is special in that the task-process "is forced" to include, or brings to appear as, a series of decisions on which activity, in connection with the problem apparatus, could be thought to lead to the goal. These decisions are registered. The sequence of decisions constitute the solving "process", and the work consists there after in characterizing this sequence on the basis of the models we have taken as our starting point. A more elaborate description of the registration and the basis for analysis of this characterization will be described in a subsequent mimeographed report."

Many of th. reasonings stated in this quote are also applicable to the present project: the inadequanteness of finished product analysis; the importance of process-studies; and the view of "the process" as a series of situations

Personal background:

As mentioned in the introduction, it has been the acknowledged practice in research circles, that the researcher's own person did not show through in scientific reports. This can have the favorable effect that the reader more easily can hold his interest in the work itself and not be intruded upon by the researcher's personality.

This point of view can, perhaps, still have relevance in research where the registration of data is done by means of a physical apparatus. In psychological research, though, where an important part of the registration apparatus is the researcher himself, a human being, it must be brought to the reader's attention if the researcher has qualifications, characteristics and attitudes, which directly influence the more important aspects of the project for reasons of objectivity.

In this case, my personal experiences, concerning the learning of mathematics, include strongly positive, strongly negative and neutral experience phases - all three of many years duration in different segments of the school and educational systems.

The negative experiences in learning can still, many years after, bring about very strong feeling of helplessness and frustration. There was some doubt, because of these negative feelings, as to whether or not the project should continue with the author as its leader. A very comprehensive project proposal was worked up (Poulsen, 1971), was thoroughly discussed with colleagues at the Danish Institute for Educational Research, and was given the green light, but it was still difficult to begin. Was the involvement too strong? Would the project be biased by this to an unacceptable degree?

The dissolvment of doubt came gradually and by way of preliminary experimentations, in which the author came in personal contact with various subjects. It became apparent in these trials, that because of the author having had precisely these very negative experiences in mathematics learning, the subjects who had had similar experiences related more frankly, their own frustrations in learning situations. Gradually, it became clear that what before had been a source of error, a weakness, became, in fact, a strenght - a special source to a deeper empathetic understanding.

In the long period from 1970 to 1973, where work on the project was almost stopped (because of other commitments), the time was used, amongst other things, in developing a new orientation in research work models, characterized by action-research, where data collection and data application go hand-in-hand. This new orientation is a consequence of critical reflections on education, and on their quality of their own research, made by a group of colleagues at the Danish Institute for Educational Research - contemplations that are still developing and that grow in extent.

The author has, in other words, difficulties himself in learning mathematics and has great limitations in mathematical profiency. This os one of the reasons, that a consultant is attached to the project (a high school mathematics teacher) as a resource person, concerned with the mathematical subject matter of the project.

ASSUMPTIONS AND VALUE JUDGEMENTS

Choice of research subjects and learning situation:

If one examines classical textbooks of psychological research of human learning, with special attention on the choice of subjects, it will become apparent that surprisingly many have been students, school pupils or pre-school children.

Surprisingly is perhaps not the correct word, but it is remarkable that the age group up to 20 or 30 years old appears to have made up the subject source for the vast majority of experiments and studies. The explanation can be simply that they were the easiest for the psychologist to get a hold of - or that researchers did not find it worth the trouble to concern themselves with adults over 30; perhaps it was not felt that they would be learning more. Whatever the reasons, the above mentioned asymmetrical age destribution is a fact.

A second remarkable characteristic of earlier research is the often mentioned problem of "transfer", ie., the transference of the results of psychological learning research from the laboratory to, for example, the classroom. This transference appears to offer many difficulties (see, for example, Grundin, 1971); so many so as to almost require investigation of the transfer process. One can see a malignant circle beginning to take shape. A characteristic of the laboritory-oriented research is that it recoils from tackling the reality, where the learning takes place, and elects to work with highly controlled learning situations, where the results are precise - but are often unusable in their original form for the practical educationalist.

With this experience as a basis, and with the improved research methods now available, it is tempting to try to eliminate the problem of transference by delimiting some of the vital situations of the daily learning activites of man, and then study and analyze these extracted segments in their own, complicated entirety.

These two observation, on the choice of research subjects and situations, can inspire the conjecture, that, what determines research results' validity range, more than anything else is precisely the choice of subjects and learning situation. In other words, the results are applicable most likely only to those persons their social level and those learning situations used in the research design.

Obviously, within this lies an abandonment of the ambitions of decades to ascertain and formulate general laws for man's learning - natural laws from which educationalists could deduce practical methods; just as one can deduce from the natural laws of physics, how much velocity a rocket requires to reach the moon.

Never! If we, at the present stage of educational/psychological research, have any ambitions of obtaining practical, usable results, the closer, local perspective must dominate.

It is always easier to have hindsight.

With the methods available to date, and with a strong desire to imitate research in the natural sciences, it is understandable that researchers avoided the confusing and complicated learning situations of everyday life, and instead attempted to analyse the results of artificial learning and problem solving experiments. But, if the psychological learning research results of the future shall contribute pronounced to pedagogical development, the classical methods must be replaced with the new. Product analyses are to be supplemented ed with process studies; artifical learning situations are to be replaced with more realistic situations.

And whom shall be the concern of this project?

Once more, we should examine the currently used and prefered subjects, especially high school and college students. Connected with their age is the fact that, because of their educational institution, there is a clear reference to especially priviledged; they are children and youth, who

have had the best educational possibilites. In other words, if one wishes to obtain a more socially justifiable distribution of the educational/psychological research, it is only reasonable to choose educationally underpriviledged adults over 30 years old as the subject group.

It is not my intention to attempt a larger documentation here, that this subject group's situation is quite different with respect to education.
Let it be rather stated as several assumptions:
1) that most educational and instructional offers, actually are directed to those under 30 years old; 2) that conditions for the educationally underpriviledged adult are made still more difficult by the fact that the examination structure requires of them, that they start their educations unreasonably low in the system; 3) that it is precisely these educationally deprived over 30, who are the first to withdraw, regardless whether it is highschool-level, recreational learning, shorter occupational courses or another form for education, (the average age in many adult education courses in Denmark is falling); 4) that these adults - regardless of whether or not they receive an education later in life - have more difficulties getting qualified employment; and 5) that this group is exposed to concrete economical hindrances, and also - especially when we go up in age - are held back by the widespread myths on adults' inferior abilities to learn.

The choice of situation is more difficult, but is determined in reality for this project, by the author's experiences, which primarily are concerned with research and development of individual study methods for use in educations focusing on literary and intellectual skills (as opposed to the just as important educations which focus on practical, manual training). However, behind these experiences lies a selection based on some considerations concerning the value of several different learning situations, which usually are a part of such educations; ie., individual study - work in small groups - and class work. In the late 1960's an

appraisal of the research in mathematics teaching showed, that the largest research contribution by far concerned class teaching methods or methods for individualized teaching: in other words, the teacher and teaching materials. The students' learning processes (differentiated from statistical descriptions of proficency, mathematical abilities, attitudes, social background, etc.), have been almost totally ignored. Let it remain a supposition that is accepted as valid - and not just concerning the subject of mathematics - that the majority of the practically oriented educational/psychological research is limited to the person of the teacher (teaching methods) and the use of teaching materials. There has also been research with more collective participant-directed educational structures - but, the single participant's individual learning processes have been hardly touched.

The choice of Subject:

The choice of research persons and priority of learning situations are based upon value judgements. Learning, however, happens always in relation to something, a subject, a theme, a problem presentation, etc. Historically - as this as well as all other projects has a prior history (the H.C. Ørsted Institute Investigation; Poulsen, 1968, 1969 & 1970) - this project is associated with the subject of mathematics. It was natural, therefore, to build upon this association - natural, but, as was seen, not especially well founded, and there came a year-long pause, where the work was put aside, partially because of other work, but also, to a high degree, because of doubt as to the value of continued research in mathematics teaching. In the projects original form, the meaning was to develop better study methods for mathematics learning in high school. The critical development in the field and in research in general, that took place in Denmark in 1968-1970, resulted in new considerations. Concerning the choice of research persons, it seemed more and more unjust to allow the project again to favor the high school students. The choice gradually became youth not entering highschool and finally became the educationally underpri-

vileged over 30 years old.

Remaining were many other questions, but one of the most pressing was whether or not the choice of the mathematics subject could be justified satisfactorily, or whether the project should have a totally new subject matter. This question remained unresolved for a few years while work on a book on documentation in educational psychology was completed (Poulsen, 1975). The impulses which set the project going again were two: Thursday, March 8, 1973, there was a little article in Politiken (pg. 7) (a large Danish newspaper), concerning a statement made by the president of the National School psychologists Association, Anders Poulsen. He drew attention to the fact that teaching of the new math, in the 1st. and 2nd. school years, had resulted in an increasing number of referals to psychological testing. In the following days, the statement was the object of lively discussion, especially amongst the teachers of the new math., who advanced the positive aspects of it. There remained though, an impression that more children were referred to the school psychologists and that there was a social bias - that precisely the subject of mathematics was the cause of an early and socially determined segregating of certain children for special treatment. The other impulse was stimulated by two books: the first, "Skolebog Nr. 1" (School book number 1) by Jesper Jensen and Per Schulz (1971) and the second, "Matematikken i Samfundet" (Mathematics in Society), by Jens & Karen Høyrup (1973). In both books, though most fully developed in Høyrup & Høyrup, there is demonstrated a connection between mathematics curriculum and the present, specific social order and especially the one-sided political slant of the example material for the more practical themes within arithmetic and numbers training.

These books contributed inspiringly to the following question: "Could it be possible that the present mathematics curriculum early favorizes children, who through an enriched language development are accustomed to abstract thinking and the use of symbols, that this curriculum handicaps children from less privileged social environments, in regards

to satisfactory achievement in this subject; and that low achievement in precisely this subject, throughout the school system, comes to function as a social class filter (because of the precedence given it by teachers and the increasing inclusion of mathematical reasoning in other, related subjects) - a social class filter which contributes to the fact that children and youth from socially less priviledged environments imperceptibly, but definitely, turn away from the subject of mathematics and those educations, where mathematical proficiency is considered to be an important prerequisite. One can visualize just how such a development could be accelerated in a school system, where any number of subjects are optional.

In other words, the subject of mathematics stands out as one factor, which very easily cna have a connection with the socially determined educational gaps.

It was with this perspective in mind, that the project was restarted, with the fundamental point of view, that precisely the subject of mathematics, for educationally underpriviledged adults, can be one of the greatest barriers to further education.

Other reasons, which are secondary in this connection, are 1) the importance of mathematics as a key to other subjects, ie., Physics, Chemistry, Technology, Social Sciences; and 2) the fact that mathematics is a difficult subject. The degree of difficulty though, is not an easy concept to deal with, as it does not say anything in absolute terms, but rather, only as a relationship - the relationship between an individual's competence and the requirements determined by either himself or others. This is the cause of a rewriting of textbooks in a more easily understandable language, amongst other things. At a more everyday level, statements about the difficulty of mathematics are determined by deeply lying personal experiences. It seems especially to take peoples' courage from them, when they, after a half day's intensive work, still cannot understand

the textbook's description, still cannot solve the problem. This experience can have a deeply frustrating intensity - but, such "difficulties" can happen in any subject and cannot be applied therefore as a special arguement for choosing the subject of mathematics.

THE PROJECT'S ORGANIZATION

A research project can be seen as a temporary social subsystem. One could suppose that it is a purely practical matter, how the work in this sybsystem is organized; but as Gitte Haslebo points out, (with support in Argyris' analyses), this is not the case. The system's organization mirrors a value judgement in whether or not it is a closed and authoritarian, or an open and democratic system. The prior term refers to a pyramidal structure, wherein the researcher is at the top of the pyramid and directs some assistants, who again direct some research subjects, whose sole assignment is to accept and fulfill the roll the researche as assigned them. The latter term expresses a form of research where all who are included in the project - the researcher, his assistants, the subjects and others - make the necessary decisions together, in the more or less foreseen situations where a choice must be made.

It is tempting to strive for the open, democratic model of organization. It is a form, which also ensures greater probability for beneficial application of the results - precisely because the people, who will be potentially utilizing the material have been included in the direction and working out of the investigation.

Seen realistically though, it must be assumed that this project, at least in the beginning, will be strongly directed by the researcher. It is my intention, however, to gradually attempt to employ a more open structure.

PERSPECTIVES

Teacher-directed Learning in the School

In the first phases of the project, there is a close association to a school teaching situation. The research persons come from highschool classes for adults and they are requested to take part by the school administration and the teachers; furthermore, many mathematics teachers from the school have exhibited great intrest in practical application, on an experimental basis, of the results. As most people's literary, intellectual learning activity unfolds within the framework of a traditional school situation, it is important that the educational research be concentrated in illustrating the learning in an institutional situation.

Antecedent to the project though, lies a vision that goes further than this basic framework.

In an organized, administrated school situation, it is characteristic that people are sharply divided, with teachers on the one hand and the students on the other. An important relationship, which usually is considered to be defining for the teacher, is his proficiency and accomplishments in, and his attitude towards the subject matter, which must be developed in the students, who do not have this professional ballast previously. The development of the students' knowledge, proficiency and attitudes is encouraged by their experiencing the teacher's instructional practice (teaching methods) and by themselves having a learning activity (study methods).

The basis for my vision is the following two observations:

1) that proficiency and accomplishments in, and attitudes towards the teaching methods employed, which teachers have, are not attempted to be developed in the student parallel to the development of the comprehension of the subject matter. The teacher gives his technical competence to his students, but <u>not</u> his knowledge about the teaching methods <u>not</u> the pedagogical.

2) that the teacher is interested in and tries to influence the students' learning products (pro'' em solving, lectures, written assignments, etc.), but not their learning processes, not their study practices. If the exceptional occurs, and a teacher involves himself in the students' study methods, it is usually as a form for further adjusting to the teacher-directed teaching arrangement.

The result of this is that most people, children and adults, have the impression that one can only learn somethir in a traditional, organized teaching situation. The learning becomes dependent upon whether or not there is a teacher in attendence in a definite institutional setting - students can neither self-direct larger individual learni 3 projects, nor can they teach one another, that which they have gotten out of their studies.

Self-directed and Collective-directed Learning Situations

My vision isthat the individual has the potential to direct self his learning jointly with others, and do it independently of an organized, teacher-centered instruction situation. People can, for themselves, formulate that which they wish to learn: search for, discover, and collect expertise, data, and materials related to the subject matter; plan, organize and realize their learning; and finally evaluate the process and the finished result, so that there can be advanced constructive proposals for improvement for the next learning project.

This does not make schools and teachers superfluous. The school's primary function becomes teaching people to direct self their learning activities and to be able to teach others, as soon as they have self obtained proficient expertise in as specific area. The key words here are self--directed learning processes and reciprocal instructior.

Schools, which have these two relationships as their primary goals, will naturally still have a use for teachers. These teachers' competence though, will be both technical,

instruction methodological and study methodological. And, they will not monopolize their knowledge of the two latter educational factors.

Such a combination has, as far as is known, never been systematically attempted. In the Latin Schools of the Middle Ages, the older students thrashed Latin into the younger students, but any form for reciprocrisy was not quite to be found. In modern universities, many students are employed as instructors, but again, this can hardly be seen as training in equal, recriprocal instruction.

Instruction in study techniques and training in reading are common, but first and foremost, deal with adjustment to a teacher-directed learning situation.

Regarding the present project, if the first phase is a success, then the next phase will be an attempt to motivate educationally underpriviledged adults to learn mathematics through recriprical instruction and selfdirected learning processes; in other words through <u>collective learning</u>.

CONCLUDING COMMENTS

It has been said, that there are many different things which taken together make up the "motives of the researcher". Which factors, that most determine the project's more exact content, are difficult to point out at present - they will appear in the course of the project.

But, to have shorn greater part of the preconditions and value-judgements for example, the gaps in the research and the study methodological possibilities - would be, simply, after the common definition of the word, manipulation of the readers. The few pages it costs extra are a little price to pay for the openness, which is created in regards to the "actual" goals of the project.

And, such an openness is a necessary prerequisite for a democratic cooperation, with the research persons and the practically working mathematic educationalists.

REFERENCES

Bushwell, G.T. & Kersh, B.Y. Patterns of thinking in solving problems. Los Angeles, Cal.: University of California Press, 1956.

Dienes, Z.P. Building up mathematics. London: Hutchinson, 1960.

Grundin, H.U. Transfer eller vad som lärs i det som synes läras. (Transfer - what is really learned) Skolepsykologi, 1971, 8, 125-138.

Haslebo, G. Samfundsvidenskabelig målforskning som interventionsform i samfundet. (Applied social science as intervention in the society) Nordisk Psykologi, 1971, 23, 402-414.

Høyrup, E. & Høyrup, J. Matematikken i samfundet. (Mathematics in society) København: Gyldendal, 1973.

Jensen, J. & Schultz, P. Skolebog nr. 1. En bog for voksne. (School book no. 1. A book for adults) København: Reitzel, 1971.

Jensen, J. Aa. Indlæring og deltagerforudsætninger. (Learning and the individuals prior capacities). København: Munksgård, 1970.

Jensen, J. Aa. m.fl. Forløbsbeskrivelse i opgaveløsning I. (Description of problem-solving processes) København: Danmarks pædagogiske Institut, 1974.

John, E.R. Contributions to the study of the problem-solving process. Psychological Monographs: General and applied, 1957, 71(18), 1-39.

Kaplan, J.D. An example of student-generated sequences in mathematics instruction. The Mathematics Teacher, 1964, 57.

Land, F.W. (Ed.) New approaches to mathematics teaching. London: Macmillan, 1963.

Newell, A. On the analysis of human problem solving protocals. Working paper. Pittsburgh, Pens.: Carnegie-Mellon University, Computer Science Department, 196?.

Nissen, T. Indlæring og pædagogik. (Learning and podagogics) København: Munksgård, 1970.

Poulsen, S.C. Oplevelse af egen studieadfærd. (The study-habits of mathematics students) København: Københavns Universitet, 1968.

Poulsen, S.C. Studievejledning Matematik 1. (1. og 2. udgave). (How-to-study guide in university mathematics (The second edition has been translated into English as mineographed report no. 8)) København: Københavns Universitet, 1968 og 1969 a.

Poulsen, S.C. Studiemetoder. (Study-methods) Uddannelse, 1969b, 2, 354-364. (Translated to english as duplicated report no. 6).

Poulsen, S.C. Efterundersøgelse af 46 matematiklinjestuderende. (Follow-up on 46 mathematics students) København: Danmarks pædagogiske Institut, 1970.

Poulsen, S.C. Den individuellle indlæringsproces ved tilegnelse af matematik. Forslag til et pædagogisk-psykologisk forskningsprojekt. (Original research preposal for the SIM projekt) København: Danmarks pædagogiske Institut, 1971.

Poulsen, S.C. Litteraturstudier som led i pædagogisk-psykologisk forskning. (Documentation as a vital part of educational research) København: Danmarks pædagogiske Institut, 1975. (In print).

Tough, A. Learning without a teacher. Toronto: Ontario Institute for Studies in Education, 1967.

MIMEOGRAPHED REPORTS FROM THE DANISH INSTITUTE FOR EDUCATIONAL RESEARCH

1. Jansen, M. Teaching of reading - without methods. On the teaching of reading in Denmark. 64 p. 1970.

2. Poulsen, S.C. Study skills and mathematics achievement. A pilot study. 23 p. 1970.

3. Poulsen, S.C. Efterundersøgelse af 46 matematiklinje--studerende. (A mailed questionaire study with the subjects from the investigation described in report no. 2. A three year follow-up on university achievement, drop-out rate or change of education. A one--page english summary can be obtained free of charge). 56 p. 1970.

4. Møller, S. Kreiner. Statistisk analyse af læsehastigheden ved højtlæsning. 1. del. (Analyses of reading speed test results. Only in danish) 212 p.

5. Leerskov, A. Meddelelsesbøger og elevbeskrivelse. Overvejelser og oplæg til en undersøgelse. (Communication between teachers and parents. Only in danish) 42 p.

6. Poulsen, S.C. The scientific basis of our knowledge about study methods. 17 p. 1973. (Translation of an article).

7. Jensen, J.A., I. Svennild og O. Bredo. Forløbsbeskrivelse i opgaveløsning. I: En beskrivelse af opbygning og funktion af et apparatur til brug for studiet af løsningsforløb inden for opgaveløsning. (About a problem-solving study. See page 10 in this report). 30 p. 1974.

8. Poulsen, S.C. "How-to-study" methods - where did they go? (Translation of an article). 16 p. 1974.

9. Poulsen, S.C. "How-to-study" guide: Mathematics 1. (Practical how-to-study guide. Based on the study described in report no 2. Distributed to many hundreds of mathematics students. Unfortunately no evaluation of the outcome was ever made) 25 p. 1974.

10. Allerup, P. og P.E. Jensen. Udviklingstendenser i specialundervisningen. (Trends in remedial and special education. Only in danish). 79 p. 1974.

11. Poulsen, S.C. Det psykologiske interview som en forskningsmetode: Litteratur om aktionsforskning og interviewmetodik. (Literature about the interview as a psychological research method and action research) 18.p. 1974.

12. Poulsen, S.C. Det psykologiske interview som en forskningsmetode: Placering af metoden i en større forskningsmæssig sammenhæng. (The interview as a psychological research method viewed in a broader research-and-developmental perspective. Only in danish). 25 p. 1974.

13. Poulsen, S.C. Projekt studiemetoder i matematik: Forudsætninger, antagelser og perspektiver. (Translated into this report no. 18) 30 p. 1975.

14. Jensen, J.A.; Bredo, O. & Svennild, I. Forløbsbeskrivelse i opgaveløsning II. Registrerings- og analysegrundlag for løsningsforløb. (Continues report no. 7) 193 p. 1975.

15. Danmarks pædagogiske Institut. 62 s. 1975. (Report about twenty years work at the institute, an overview with a selected bibliography. Will possibly be translated in the fall of 1975).

16. Allerup, P. & G. Sorber. The Rasch Model for Questionnaires with a computer program. 72 p. 1975.

17. oulsen, S.C. Beskrivelse af pædagogiske forsknings- og udviklingsprojekter. (Suggestion for a short standardized description of research and development projects in educational research). 6 p. 1975.

18. Poulsen, S.C. The study-methods in mathematics (SIM) project I: Back ground, assumptions and perspectives. 34 p. 1975. (An english translation of report no. 13).